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ABSTRACT

This report reviews experimental techniques that have been used to assess sentence comprehension by preschool children and describes a new technique, word monitoring, which permits an assessment of the momentary demands made upon sentence-processing mechanisms as a child listens to a sentence. (The time it takes the child to push a button in response to a target word is the main variable in this technique.) Four experiments using the technique are described. The first explored the word-monitoring task to see if it would yield sensible data in a "clear case" situation. In succeeding experiments, various hypotheses concerning the processing of sentences that contain relative clauses were examined. In particular, Slobin's Interruption Hypothesis and Sheldon's Parallel Function Hypothesis were tested. Evidence in favor of the Interruption Hypothesis was obtained: children at this stage appear to enter into a processing subroutine when the cue word "that" appears, signaling a relative clause. Further work showed that children do not overgeneralize; they do not take the cue word "that" to be a signal for a relative clause when it is inappropriate for them to do so (e.g., when "that" is a demonstrative). (Author/AA)

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FINAL REPORT

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# LANGUAGE COMPREHENSION IN CHILDREN

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## Preface

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## Introduction

The research project to be described here falls under the general heading of developmental psycholinguistics. In broadest terms the aim of research in this area is to understand the acquisition of language. This is a problem area that is among the oldest in psychology (see Blumenthal, 1970, for an historical review) and, at the same time, has been one of the "new" areas of the past twenty years. One major reason for its newness is that the linguistic revolution spawned by Chomsky (1957, 1965) gave psychologists a new way of looking at and characterizing the problems of language acquisition. Although very few present-day workers in the area subscribe very closely to Chomsky's linguistic views, and although it has become somewhat fashionable to say that Chomsky's ideas were of little benefit to the area, there can be no serious doubt that Chomsky's formulations did permit researchers to see the problems of language acquisition in a new light. In fact, his insights have permitted us to state some of these problems (though not all) with considerable clarity.

It is reasonable to state that the goals of developmental psycholinguistics include the following: (a) to construct a description of the knowledge of language that children have at various points in their development; (b) to describe the processes that children use in producing and comprehending utterances and discourses; and (c) to describe the principles of development that govern the first two. It is obvious that these are interdependent goals. Any theory of linguistic knowledge will have immediate implications for a processing model of comprehension, and vice versa. For example, the theory of knowledge will specify the entities that the processing model will have to compute and use during its operation. That is, the processes must result in structures that are stored in the knowledge system of the language user. And, to the extent that we can specify what procedures the young comprehender is using, these procedures, as well as their products, constitute part of the knowledge of the child. In fact, since the hypothesized knowledge structures are grossly underdetermined by the data, and since certain types of data, such as linguistic intuitions, are very difficult to obtain from young (pre-school) children, attempts at constructing processing models of comprehension and production may be a reasonable strategy even for the theorist who is primarily interested in describing the child's knowledge and its development.

Meeting goals (a - c) would, obviously, take us a long way toward understanding the mind of the child. And this would put us in a much better position than we now find ourselves when asked such questions as: What does it mean for a child to be "ready" to read? Or when is the child outside the normal range in his or her language development?

Over the past two decades there have been a large number of studies whose primary aim has been to describe children's knowledge structures and the way they change as children acquire language. Most of the grammar-writing projects ably summarized by Brown (1973) fall under this heading. And over the past decade there have been an increasing number of studies that are aimed more at the processing issue than at the knowledge issue. The work described below is a member of the latter category. It is concerned with sentence processing and models to account for it.

## Preview

The present work has two major foci. One is to develop a technique that permits us to assess the momentary difficulty that children are having as they comprehend (or try to comprehend) a sentence. The other is to investigate the acquisition of certain types of complex sentences. We are hopeful that the pattern of development for these structures will help to tell us something important about the acquisition strategies that children utilize during the pre-school period.

In the next section of the report we discuss the first of our foci, that having to do with methodological considerations. First a review of the existing measures of comprehension is presented. Some assessment of the processing demands made by each of these tasks is also given, although this is not done in great detail here. Since the measure that we have developed makes use of reaction time data, we next review the literature on the use of this dependent variable with children, and try to show how our technique fits into this tradition. A description of and rationale for the present methodology is then given. Later we will have to note that, while useful, our technique is no panacea and that other kinds of data must be used in conjunction with it in order to appropriately interpret the results of studies employing it.

The report then turns to the second focus, tracing through a set of experiments that were conducted to investigate the acquisition of sentences containing relative clauses. As the reader will note, this section also describes modifications in our thinking about methodological issues.

The first experiment was a demonstration experiment, designed to test whether the new method would work in a clear case. The remaining studies tested various hypotheses, some devised from Slobin's (1971) proposed set of universals of language acquisition, and some that we informally devised from a computer-based model of sentence parsing. These ideas will be presented in more detail at the appropriate points in the narrative. Our general conclusions from this work are presented later in the Overview section.

# Methodological Considerations

## Comprehension Tasks and their Processing Demands

One of the things that stands in the way of progress in modeling comprehension is that our knowledge about what kinds of sentences children find difficult at various stages in their development is quite limited. Further, to the extent that we do know what types of sentences are troublesome for children, we usually do not know where within those sentences processing gets difficult and the child's comprehension goes awry. It would seem that information of this latter sort would provide the kinds of constraints that we need in order to make progress in building models of comprehension and its development.

Most of the experiments having to do with sentence comprehension in children have as their dependent variable a measure that primarily depends upon the child's memory. In consequence, the assessment of comprehension occurs after the act of comprehension is complete. In addition, many experimental tasks require that the child organize a fairly complex response, either verbal or non-verbal. Thus, the assessment of comprehension may be influenced by the difficulty of organizing

and executing the response. Although the data gathered in such experiments are valuable, they do not always permit one to make a very fine-grained analysis of what the child is doing during sentence processing. Furthermore, there have not been many attempts at detailed analyses of the experimental tasks. It is our view that a theory of sentence processing will not emerge from such experiments until we make an explicit set of assumptions about the manner in which the experimental task influences the results. When a memory paradigm is used, the conclusions that one makes about sentence processing depend upon the assumptions that are made about the nature of the child's memory and how it affects the dependent variable. See Fillenbaum (1970) for further remarks along similar lines.

In order to give some substance to the above views, we will briefly review some of the more common tasks that have been used to assess the child's comprehension of sentences. We will not attempt to give a detailed analysis of the cognitive demands made by each task since the amount of speculation involved would be too great. Instead we will give only a preliminary sketch of what those demands might be. In this brief survey we do not discuss any experiments in detail nor do we necessarily cite the first investigator who used a particular technique.

Both verbal and nonverbal tasks have been used to examine a number of lexical, syntactic, and semantic variables. Among the tasks that involve a verbal response, one that is apparently quite straightforward is elicited imitation. Slobin and Welsh (1973) asked children to imitate sentences that were longer than their immediate memory spans. If an imitation preserved the meaning of the sentence, the child was presumed to have comprehended it. Since the sentences to be imitated were typically longer than the child's memory span, elicited imitation required that the child construct an internal representation of the sentence that did not preserve all of its surface features. This is a positive feature of the task since listeners typically do not retain surface information for very long during comprehension anyway (e.g., Sachs, 1967). On the other hand, asking children to imitate a sentence requires that they <u>try</u> to preserve the surface information and it requires them to organize their production of the input sentence. Both of these, especially the former, may interfere with the ongoing comprehension of the input sentence. (Slobin and Welsh were aware of these possibilities.) Storing additional surface information may require use of memory mechanisms that are required by some of the comprehension "subroutines." It is possible that such interference would have differential effects on different sentence types.

Similar to elicited imitation is the paraphrase task. For example, Schultz and Pilon (1973) presented ambiguous sentences to 4- and 5-year olds and asked the children to paraphrase them. Based on the subjects' paraphrases of the sentences, the authors drew such conclusions as, "the ability to detect linguistic ambiguity develops at different rates depending on the type of ambiguity" (p. 732). The paraphrase task does not require the storing of surface information and so may not interfere with comprehension as much as the elicited imitation task. However, it would still seem that paraphrasing puts a heavier load on memory than "normal" comprehension since the listener may often store the surface information anyway in the belief that it will be important for guiding paraphrases. Also, the act of constructing a paraphrase (finding synonyms, etc.) may in part occur while the sentence is being heard and these processes may

compete with comprehension for processing space.

Verbal reactions to questions or commands comprise another group of tasks that involve verbal responses. For example, Shipley, Smith, and Gleitman (1969) recorded the responses of 18- to 33-month olds to commands which were either well-formed or shortened, telegraphic versions. Similarly, the role of word order in two- and three-year old children's comprehension has beeen investigated using responses to questions by Wetstone and Friedlander (1973). The latter investigators manipulated word order and observed the answers children gave to such questions as, "Truck the where is?" Potentially this would appear to be quite a sensitive measure since one could manipulate the points within a sentence where standard order was violated and observe whether differential effects occurred in answering the questions or following the commands. (Using RT techniques such as those to be discussed later along with the word order manipulation might be even more useful.) The work of Chomsky (1969) provides another good example of the attempt to assess comprehension by the use of verbal responses to questions and commands. She found it useful to have toy props such as dolls toward which some of the child's responses could be directed.

These tasks have a high degree of apparent ecological validity. Children are asked a lot of questions and given a lot of commands. Useful information is likely to result from such studies. However, the tasks are subject to the possibility that the child's comprehension score is in part a function of how well he can organize and carry out the command or how well he can construct the answer to the question. The degree of contamination that this might bring to the results will vary from study to study. In addition, we don't know the manner in which violations of word order or other anomalies are detected and what the detection of such a violation does to the comprehension of the rest of the sentence.

Another type of verbal response requires judgments about sentences or about the relations between two or more sentences (e.g., grammaticality or synonomy judgments). Thus, Gleitman, Shipley, and Alloway (1970, cited in deVilliers & deVilliers, 1972) had two-year olds judge sentences as "good" or "silly." To investigate the effect of word order, the authors had the child's mother read sentences like "Eat the cake" and "Cake the eat" to the child. Children judged sentences with proper word order as "good" significantly more often than they so judged sentences with reversed word order. This method was altered somewhat by deVilliers and deVilliers (1972). They had children between the ages of 28 and 45 months "help teach a puppet to talk properly." The puppet would say a sentence in either proper or reversed word order. Then the child would judge the sentence as "right" or "wrong" and, after a "wrong" judgment, the child was urged to tell the puppet "the right way to say it." The same procedure was used to test each child on his or her comprehension of semantically anomalous sentences. The authors found that semantic anomaly could be detected at an earlier age than could reversed word order. The advantages of the "child as anomaly detector" and the "child as language teacher" techniques are similar to those of the "response to commands" technique. It is possible to manipulate systematically the type and position of the anomaly to see whether the child is sensitive to the violation. The disadvantages are also similar. The effects of a violation may carry over and affect comprehension of other phrases or clauses of the input string. It is also not clear what effect monitoring for anomalies has on the comprehension processes. Looking for mistakes or "silly" sentences may involve a type of processing, and attendant shifts in

the allocation of central resources, that is different from more normal processing.

In another judgment task, Quigley, Smith, and Wilbur (1974) presented deaf and hearing children with a written, relativized sentence and four simple sentences. Among other tasks, the subjects were asked to judge which simple sentence was synonomous with the relativized sentence. Such judgment tasks require holding two or more sentences in memory and making some complex comparison among them. The demands of such a task appear to be unlike those of normal comprehension and it seems questionable whether such data will be very helpful in constraining models of comprehension.

The simplest nonverbal response used as a measure of sentence comprehension is the reaction to a command, though the complexity of the required response might negate this generalization. Bühler and Hetzer (1935, cited in Fraser, Bellugi, & Brown, 1963) tested children's understanding of commands like "get up" and "give that to me" by simply observing their reactions to the commands. This procedure has been refined in many ways. For example, in her study of the "easy to see" construction, Chomsky presented a blindfolded doll to a child and asked "Is this doll easy to see or hard to see?" If the child responded "hard," then the experimenter asked the child to make the doll easy to see. Likewise, a child who responded "easy" was asked to make the doll hard to see. This study looked at both verbal and nonverbal responses. In her study of children's understanding of the word "promise," Chomsky presented the subjects with dolls and then read sentences like "Bozo promises Donald to do a somersault. Make him do it." Thus, by observing the child's manipulations of the dolls, Chomsky could tell whether or not her subjects understood the syntactic structures associated with "easy to see" and "promise." Shipley, Smith and Gleitman (1969) observed nonverbal (as well as verbal) reactions to shortened and well-formed commands. They recorded the "objects looked at, touched, and played with, as well as verbalizations within the 90-second interval after the [command]" (p. 327). They used these data to evaluate whether telegraphic or full commands were most effective to the subjects.

Toy moving tasks similar to Chomsky's have been used by many investigators. For example, Huttenlocker, Eisenberg, and Strauss (1968) presented subjects with a three-piece road with a red truck on the middle piece. Then the child was given a green truck and was read such sentences as, "The green truck is pulled by the red truck." The authors recorded the amount of time required for the subject to make the appropriate placement of the truck. Toy moving has also been used to investigate the comprehension of terms like before and after (Clark, 1971). Clark presented her subjects with sentences like, "Before the boy patted the dog he kicked the rock," and had the children act out the sentences' interpretation with toys.

Both tasks, responding to commands and toy moving, have yielded data useful to theories of comprehension. One possible problem with such techniques arises when they are used to investigate two-clause sentences (a la Clark). In such situations children may fix their gaze on the first actor, on the relevant instrument for the first action, etc. In other words, the subjects may be able to do some "place-keeping" by using such tactics as gaze direction or organizing initial responses while still processing the input sentence. Recently, Rommetveit (1976) presented wome data which support the importance of such "place-keeping" variables. When seven-year olds were shown a picture of some men and asked to find "the heavy man with the light work," they were able to do so as long as the

picture was in front of them. If, however, a page had to be turned after hearing the sentence, the child made many more errors. Again, the degree to which such factors might arise, and their interpretation, will vary from study to study.

Another nonverbal task involves verifying whether pictures match sentences. This work will be reviewed in the next section on reaction time.

The last group of tasks involving nonverbal responses to be considered here is based upon choices made by the subject. Individual lexical items can be tested quite simply. Gesell and Thompson (1934) placed several items on a table in front of a child and then asked, "Where is the X?" If the child looked at the proper item it was inferred that he know the meaning of "X." Maratsos (1973) found that most children from 4 1/2 through 5 years of age think of "big" as meaning "tall," as evidenced by the item they pointed to when told to choose the "big" one. Several other constructions have been investigated the same way, e.g., "more/less" (Townsend, 1974), "long/short" (Donaldson & Wales, 1970).

Fraser, Bellugi, and Brown (1963) tested children's understanding of ten grammatical contrasts with a picture-pointing task. In this task the experimenter read a sentence and the subjects pointed to one of two pictures, the one they thought depicted the action in the sentence. Such tasks require an encoding of the pictures and a set of comparison operations which may be quite complex. It is noteworthy that Fraser et al. recognized the importance of task analysis and provided informal analyses of the imitation, comprehension, and production tasks that they used. Further, these analyses were explicitly used in making the predictions found in their paper. Kaplan and Yonas (1967) showed the importance of other task demands (in their case, the communication situation and the questions asked of the child) in their reanalysis of the relationship between comprehension and production. Finally, Fernald (1972) has argued that Fraser et al. made some faulty conclusions because they did not go deeply enough into their task analyses.

In sum, there is a wide variety of techniques available to the developmental psycholinguist who is trying to assess comprehension. Useful data can be obtained from most of them. However, an analysis of the demands that the task puts on the child's language processing mechanisms may suggest that the child is doing something quite different from normal comprehension--and different in such a way that it is unclear how appropriate inferences to comprehension can be made. Also, most of the techniques surveyed are of uncertain validity when complex sentences are being studied. Having completed this brief survey of comprehension techniques and the highly sketchy analyses of the demands that they put on the subjects, we now turn to the reaction time literature.

## Reaction Time Studies with Children

The experimental technique that we will introduce below uses reaction time (RT) as the primary dependent variable. This variable has a long history of use with children as subjects, although the tasks that have been employed have typically been relatively simple. Hohle (1967) cites extensive work done by J. A. Gilbert as early as 1894 on the manner in which RTs to simple stimuli change with age. The studies by Goodenough (1935) and others were used to plot age-RT functions (e.g., Woodworth & Schlosberg, 1954). As is now well documented (see Wickens, 1974, for a very useful review), children's RTs are very sensitive to attentional factors that can be manipulated by incentives and by practice

effects. Hence, the "classical" age-RT functions do not necessarily represent processing time differences as was at one time assumed.

Presumably because of attentional factors, the studies that have used preschool children as subjects have almost always used simple stimuli such as lights. The trial structure of these experiments has also been such that there were few distractors. Thus, the lore that has built up concerning RT studies with children suggests that simple stimuli and non-distracting situations must be used because of the large effects of attentional factors on children's response times.

Although experimenters studying RT in children have often used variable foreperiods before the test stimulus occurred, they have not usually filled these periods with stimuli except, of course, those occurring constantly in the background. One exception to this generalization occurs in work done with the Continuous Performance Task (CPT). In the CPT the subject is presented a list of letters one at a time and is asked to respond to a specified target letter by pushing a button (Rosvold, Mirsky, & Sarason, 1956). Usually the stimuli are visually presented; most studies using the CPT have used probability of correct detection as the main dependent variable. However, Werry and Aman (1975) looked at RTs in the CPT while manipulating the drug state of their subjects. The 24 children in the study averaged seven years, nine months. The letters were presented for 1.5 sec each with an inter-letter interval of 1 sec. The RTs obtained in this study were in the .96 sec to 1.02 sec range.

We are aware of only two experimental paradigms in which RTs were gathered from young children in sentence processing tasks. One is the sentence verification paradigm (Slobin, 1966) in which children were presented with a sentence and then a picture and were asked to press one button if the picture correctly depicted the sentence and another button if it did not. Slobin manipulated the types of sentences that he presented (e.g., active, passive, negative, and their combinations) and made inferences about the ease of comprehension of these various types on the basis of the verification times that he observed. Slobin found some interactions of sentence type with age, findings which permitted him to make some interesting speculations concerning the developmental process. The verification task has been used in many other experiments, particularly with adult subjects.

Slobin pointed out some difficulties with the verification task in his 1966 paper. Verification RTs seem to be very susceptible to particular strategies that are adopted by the subjects within the confines of the task. Both Slobin (1966) and Gough (1966) speculated about the nature of these strategies. Based upon these speculations, some quite thorough models of the strategies have been proposed (e.g., Clark & Chase, 1972; Trabasso, Rollins, & Shaughnessy, 1971). These models have been criticized as both being too task specific and as not being models of normal comprehension at all (Tannenhaus, Carroll, & Bever, 1976; but see, in reply, Carpenter & Just, 1976). This is not the place to enter into this debate. Suffice to say that although models of verification have been worked out in detail, no one has made a thorough analysis of the way in which the task demands of verification affect comprehension itself.

The second paradigm in which children's RTs were gathered in a comprehension task was devised by deVilliers and Flusberg (1975). They presented two- to four-

year old children with an array of six similar objects and one that was dissimilar. They then singled out one of the objects (either one of the majority or the single item) and asked the child to complete a sentence of the form: This is a _____; or This is not a _____. The time it took the child to verbally complete the sentence was measured. Completion times varied around one sec; the authors were able to obtain significant differences in RTs with only 24 observations per child and 13 children per age group. Both the Slobin and the deVilliers and Flusberg studies are impressive in that they violate the lore about collecting RTs with children in complex tasks. Given this background, we are now prepared to describe our RT task.

Word-Monitoring

The work summarized below makes use of what we will call the word-monitoring technique. It is patterned after a similar task, phoneme-monitoring, which has been used successfully with adults. In phoneme-monitoring, adult subjects are aurally presented sentences and they are instructed to do two things. First they are told to comprehend the sentences just as they do normally. A variety of comprehension tasks, which we will not review here, have been used to check whether or not the subjects were paying attention to the sentences. The second and more important task that the listeners are asked to carry out is phoneme-monitoring. The subjects are told to listen within each sentence for a word that begins with a particular target phoneme (for example, the /b/ in boy) and to push a button as soon as they hear this target. A timer is started as soon as the target phoneme occurs in the sentence and is stopped when the subject responds. This RT constitutes the major dependent variable in the research.

Informally, users of the phoneme-monitoring task assume that the subject will not be able to monitor for the target phoneme as efficiently when the sentence is difficult to process as when it is relatively easy to process. Hence, RT will be positively correlated with sentence processing difficulty at the point where the target phoneme occurs. Phoneme-monitoring RTs have been shown to be sensitive to a variety of syntactic and lexical variables. For example, Foss (1970) has shown that RTs tend to be longer when the target occurs immediately after a rare word in the language than when it occurs after a common word. Hakes and Foss (1970; see also Hakes and Cairns, 1970; Hakes, Evans, & Brannon, 1976) have shown that phoneme-monitoring RT is sensitive to the details of how sentences containing relative clauses are constructed. Also, a number of studies have used the phoneme-monitoring technique to investigate the effects of ambiguity on the comprehension process (e.g., Foss, 1970; Foss & Jenkins, 1973; Cairns & Kamerman, 1975). Thus, there is a body of evidence to the effect that phoneme-monitoring can reflect the momentary difficulty that is experienced by listeners as they comprehend sentences.

There has been some discussion and disagreement concerning the way in which phoneme-monitoring interacts with sentence comprehension in order to yield results like those referred to above (e.g., Foss, 1970; Morton and Long, 1976). We will not, however, explore these varying points of view here since they may not be relevant to the word-monitoring task.

Preschool children are unable to segment the speech stream into phonemes with enough facility to make phoneme-monitoring a feasible task for them. (In fact, young children's inability to decompose words into their phonological constituents may be a major reason why pre-schoolers cannot learn to read with

facility. See Foss & Hakes, 1978, Chap. 10, for a further discussion of this viewpoint.) Word-monitoring is an obvious modification of phoneme-monitoring. Asking children to monitor within a sentence for a particular word might have some of the same advantages as phoneme-monitoring. That is, when the momentary difficulty of processing the sentence is high, the mechanisms that are used for word monitoring might be relatively inefficient since they are being taxed by some aspect of the comprehension process. As a result, RTs would be relatively long. When momentary processing difficulty is relatively low, monitoring efficiency might be high and the resultant word monitoring RTs would be short. We will return in the discussion to some further speculations concerning the mechanisms at work in this task. We should state here, however, that we cannot know a priori what effects the word-monitoring task might have on the normal comprehension process. The relationship between this new measurement task and comprehension will have to be subjected to analysis.

## Experiment I: Demonstration Experiment

When carrying out work with a new technique it seems wise to try it out in a situation in which it has a good chance of success. Thus, in the first study to be reported we manipulated variables that seemed very likely to affect the momentary sentence processing load of the young listener. If we could not find RT differences in such a situation, then there would be no hope for using the task to detect more subtle differences in sentence processing difficulty. The experiment used sentences like those shown in Table 1. In half of the sentences the target word was immediately preceded by a common word known to the children in the study. In the other half of the sentences the target word was immediately preceded by a nonword, an item that could not be known by any of the children. In addition, we included a second variable, the syntactic function of the target word in the sentence. Actually this latter variable was a complex and, in order to maximize the chances of observing a significant effect, a purposefully confounded one. In half of the sentences the target was a noun which occurred either in the main clause of the sentence, in a prepositional phrase, or in a for/to complement clause. In the other half of the sentences the target was a verb in a that-complement clause.

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Insert Table 1 about here

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We reasoned that children ought to be slower in responding to targets that occurred after non-words since their processing mechanisms would be busy trying to decode the unknown item and hence could not efficiently carry out the word-monitoring task. At the time when the target word occurred, the child would be busy unsuccessfully searching his mental lexicon for the nonsense word and/or be busy trying to construct an interpretation for this item from the information available in the item's context. In addition, the child may have a harder time assigning word boundaries when one of the input items is not a word.

For a number of reasons we also suspected that children would be slower in responding to verb targets in that-complements than to noun targets in the other category. Sentences with that-complements have two surface agents before the target verb, a fact tha may confuse the child; they have verbs of propositional

attitude (e.g., believe, know, think), which may be psychologically more complex (see Hakes, 1971; Harris, 1975); and such sentences simply appear to be harder to process. Given the way that we had stacked the deck in our favor, we were prepared to toss in the word-monitoring technique if neither of the variables had any effect. It would be very unlikely that any lexical or syntactic variable would lead to a difference in RT if these two did not.

## Method

Materials. Twenty test sentences were constructed, ten with verb targets and ten with noun targets. All ten sentences containing a verb as target word were complex sentences with an embedded sentential complement that began with the relative pronoun that. The target verb was always in the embedded sentence. Seven of the ten sentences containing a noun target had the target noun occurring in the anterior independent clause of a complex sentence. Two sets of materials were constructed. Each material set contained all 20 test sentences. In Set 1, half of the sentences with noun targets and half of those with verb targets were preceded by a common word that was known to the subjects (e.g., red, good, lady, children). In the rest of the sentences the target word was preceded by a nonsense word that (with two exceptions) had the same number of syllables as the real word it replaced and which ended in the same phoneme as the replaced word (e.g., zed, lud, sody, shumden). Those sentences that occurred with real words preceding the target in Set 1, occurred with nonsense words in that position in Set 2, and vice versa. Thus, each subject in the experiment heard five sentences drawn from each of the four cells shown in Table 1. The 20 test sentences were each about 12 words long. Target words occurred about the seventh word into the sentence.

In addition to the 20 test sentences, thirteen filler sentences were included in each set. These fillers ranged in length from seven to thirteen words and embodied a variety of grammatical constructions. Six of the fillers did not contain the word that was specified as target for them. These sentences were included to minimize the subjects' expectation that a target would occur before the end of every sentence. Three of these sentences contained a nonsense word (and then no target) to help insure that the subjects could not learn simply to press the button after an unknown word and thereby be responding to the target. The remaining seven sentences had the targets widely dispersed throughout them, sometimes occurring very early in the sentences (third word) and sometimes fairly late (ninth word).

The thirty-three sentences were arranged so that the first six sentences were fillers with the remaining fillers scattered throughout the list. Each of the twenty experimental sentence frames occurred in the same serial position in the two material sets. Sentences in each of the four conditions were spread uniformly throughout the list in order to control somewhat for practice effects. Each material set was recorded on tape with normal intonation by a male speaker of Standard American English.

A timing mark was put on a separate channel of the tape (it was inaudible to the subjects) coincident with the initial sound of the target word. This signal caused a relay to close which, in turn, started the timer. Target positions were found by manually moving the tape back and forth across the playback head of the tape recorder.

Procedure. Each child was brought by an experimenter from his or her preschool classroom to the small testing room. Subjects were tested individually by two experimenters, one of whom interacted with the subject while the other recorded the RTs and the subject's responses on the comprehension test, and operated the timing equipment. The child was familiarized with the tape recorder and with the response button which was mounted on a panel facing him. The child was taught how to push the button and the word monitoring task was explained to him. The child was given some practice with oral (not tape recorded) examples. If the child had any difficulty in grasping the task, the experimenter slowly said aloud a list of unrelated words which contained a target word and asked the child to push the button when the target occurred in the list. Then the experimenter would say a simple sentence which included a target. Subjects were praised for proper performance of the task.

Occasionally a subject would wait until the end of the sentence before pushing the button. When this happened the experimenter would coax the child to respond right after the word. Sometimes the experimenter would also rest his finger on the button and both child and adult would push the button together when the target occurred. This procedure was often helpful in getting the task across to the subjects. Two or three of the children could not learn to respond during the sentences and they were excluded from the experiment.

After the child understood the task, the experimenter specified the first target word. Often after the target was specified the experimenter would ask the subject if he knew what the target word meant, i.e., "Do you know what it means to 'x' something?" Since the subjects always did know, this part of the procedure was primarily useful as a way of communicating to the child that he or she was smart and helpful. In order to ensure that the child had the target in mind, the experimenter asked him, "What are you listening for?" and "What are you going to do when you hear it?" The child was asked to rest the index finger of his preferred hand on the response button and to respond as quickly as possible when the target occurred. After the target was specified and the child became attentive, the tape recorder was started and a sentence was presented free-field. If a child had any difficulty in correctly responding to the first six filler sentences, these were replayed to him. Between trials some irrelevant talk between child and experimenter was permitted in order to keep up the child's interest, but the procedures during a trial were kept as constant as possible. The child was praised for his performance, especially when he did not press the button on filler sentences containing no target word.

On approximately half of the trials the child was asked a question about the sentence in order to determine whether he was trying to understand the sentences. (For example, the child might have been asked, "Who likes to throw the ball?" after the sentence shown in the upper left of Table 1.) Although there were numerous errors in response to these questions, most were related to the sentence and not totally irrelevant. We considered relevant responses, not only correct ones, to indicate that the child was trying to comprehend.

Some children wanted to have a turn at specifying the target word and on the filler sentences they were permitted to do so. This seemed to help maintain their interest in the task (though none was successful in precognizing an actually occurring word in any filler sentence).

Subjects. The subjects were sixteen children (eight boys and eight girls) who were recruited from preschool classes at the University of Texas Child Development Laboratory. Their ages ranged from four years, one month to five years, nine months; the median age was four years, ten months. The children came from predominantly upper-middle class white families.

Design. There were five independent variables in this study: sex of subject, material set, type of item preceding the target (word vs. nonword), form class of the target word (noun vs. verb), and grammatical complexity of the sentences. For reasons noted above, the last two variables were purposefully and systematically confounded. Thus, the design was a 2 X 2 X 2 X 2 design with the first two variables being between subjects and the last two being within subjects. Only the latter two were expected to affect word-monitoring RT.

## Results

The main results of the study are shown in Table 2. The effect of the word vs. nonword variable was large (153 msec) and highly significant both when analyzed with subjects as the random variable, $F_1(1,12) = 20.07$, $p < .001$; and when analyzed with sentences as the random variable, $F_2(1,19) = 20.37$, $p < .001$. Min $F'(1,29) = 10.11$, $p < .005$. The effect due to the syntactic function of the target was also large (162 msec) and reliable, both by subjects, $F_1(1,12) = 9.63$, $p < .01$; and by sentences, $F_2(1,9) = 17.13$, $p < .003$. Min $F'(1,21) = 6.16$, $p < .03$. These two variables did not interact. In addition, neither of the effects due to sex of subject nor material set was significant; nor did these two interact with any of the other variables.

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Insert Table 2 about here

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The frequency distributions of RTs, broken down by condition, are shown in Figs. 1 and 2. The variabilities of these distributions include variance due to subjects. The distributions suggest that RTs in excess of about 1700 msec may not actually belong in the distribution but rather are "late" responses made by the child. By this we mean responses that may involve some reprocessing of the sentence or an occasional response that was actually made at the end of the sentence rather than in response to the target.

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Insert Figs. 1 and 2 about here

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## Discussion of Experiment I

The particular results that were found in this study corresponded well with the predictions made earlier. Reaction times are significantly longer when the target words occur after unknown "words" than when they follow known words. The occurrence of an unknown word presumably stimulates the comprehension mechanisms either to make a second attempt at finding the item in memory or to add the

new item to the mental lexicon (including the storing of information about its probable syntactic and semantic function, derived from context). Either of these operations could readily interfere with word monitoring (vide infra). Also, RTs were significantly longer when the target word was a verb in a that-complement clause than when it was a noun in a main clause, early prepositional phrase, or early for/to complement. Because of the variety of variables that are involved in this comparison, the observed difference could have arisen from a number of sources. One unlikely source is the frequency of the target words themselves. The nouns and the verbs were nearly all very high frequency words; all of the targets were known to the children; and, since the target words were stated before the trial began and discussed with the child, both types of targets were activated in the child's mental lexicon before they occurred in the test sentence. It seems likely that the syntactic differences between the columns of Table 1 were more important than the difference in form class of the target words, but further experiments are required to say this with assurance.

Naturally we found Experiment I to be a very rewarding study. The variables that should have shown effects on RT did so; those that shouldn't, didn't. The absolute values of RT were not too high, the differences were substantial, and the N needed to get reliable results was modest. A bit of patience and an enjoyable task (which the children seemed to find word-monitoring) appeared to be all that was required to get beautiful data. Unfortunately, things have not always worked out quite so nicely; but let us not get ahead of our story. In sum, we felt at this point that the methodological battle had been carried, and we moved to a more substantive issue.

## Processing Relative Clause Sentences

There has been a fair amount of work reported in the literature on the acquisition and processing of relative clauses. There is also a controversy about what types of relative-clause containing sentences are most difficult to process. It was upon this issue that we tried to bring to bear data gathered with the word-monitoring technique. Most of the data in the literature is consistent with what Slobin (1971) called "Operating Principle D: Avoid interruption or rearrangement of linguistic units." Slobin raised this principle to a language processing universal (his Universal D4), "The greater the separation between related parts of a sentence, the greater the tendency that the sentence will not be adequately processed (in imitation, comprehension, or production)" (Slobin, 1971, p. 354). We will call this the Interruption hypothesis. Data in support of this hypothesized universal include the well-known difficulty of handling multiply self-embedded sentences such as (1).

(1) The coffee that the mug that Esther purchased holds is delicious.

Chomsky (1965, p. 14) proposed one reason why this difficulty might arise:

> To account for the greater unacceptability of self-embedding (assuming this to be a fact), we must add other conditions on the perceptual device beyond mere limitation of memory. We might assume, for example, that the perceptual device has a stock of analytic procedures available to it, one corresponding to each kind of phrase, and that it is organized in such a way that it is unable (or finds it difficult) to utilize a procedure $\phi$ while it is in the course of executing $\phi$.

In support of this notion, Baird (1973) found that self-embedding contributed more than simply nesting to the difficulty of comprehension in subjects ranging in age from four years to college. He used a verbatim recall task in his study. Also Brown (1971) found that embedding led to poorer performance in a picture pointing task when he tested three-, four-, and five-year olds. And Smith (1974) reported poorer performance in an elicited imitation task for embedded as opposed to right-branching sentences when he tested children between 29 and 36 months of age. This pattern of results satisfies one of the major criteria for a good night's sleep for a scientist: A variety of tasks have converged upon similar results. However, not all of the results in the literature are as somniferous.

Sheldon (1974) used a toy moving task to study the comprehension of various types of relative-clause sentences in children from 3:8 to 5:5. It is worth looking at her sentence types in detail; they are shown, along with their labels, in (2 - 5).

(2) SS The dog that jumps over the pig bumps into the lion. (1.58)

(3) SO The dog that the pig jumps over bumps into the lion. (.52)

(4) OS The dog jumps over the pig that bumps into the lion. (.88)

(5) OO The dog jumps over the pig that the lion bumps into. (1.52)

The labels, SS, etc., are to be read as follows. The first letter tells us whether the relative clause modifies the subject (S) or the object (O) of the matrix sentence; the second letter tells us the role of the relative pronoun in the relative clause, subject (S) or object (O). The first two sentence types, SS and SO, embed the relative clause inside the matrix sentence. According to the Interruption hypothesis, these sentences should be harder to process than the OS and OO sentences. Other factors may be at work, of course. Thus, if sentences which do not conform to Bever's (1970) "primary functional labeling" strategy (i.e., NVN sequences correspond to actor-action-object) are more difficult to process, then SO sentences should be harder to comprehend than SS sentences.

The numbers in parentheses after the example sentences give the mean number of correct sentences (out of three possible) that were obtained by Sheldon in her toy moving task. These results do not fit the Interruption hypothesis since the score for the SS sentence type, where there is an interruption between "dog" and its verb "bumps," was high. Sheldon proposed a new hypothesis to account for her results, the Parallel Function hypothesis. It says that sentences will be difficult to process when coreferential noun phrases have different functions (subject vs. object) in their two occurrences. More explicitly: In a complex sentence, if coreferential noun phrases have the same grammatical function in their respective clauses (SS and OO), then that sentence will be easier to process than one in which the coreferential noun phrases have different grammatical functions (SO and OS). In her paper Sheldon gave some reasons for thinking that the Parallel Function hypothesis has applicability beyond the relative clause case. Also, if one goes back and looks at the data of Brown (1971), his results are found to be consistent with the Parallel Function hypothesis. They fit the latter hypothesis better than the Interruption hypothesis, in fact. The same

cannot be said of Smith's (1974) data, however. His results do not fit the Parallel Function hypothesis at all. On the other hand, they do not give very strong support to the Interruption hypothesis either. Smith found that the SO sentence type was the worst imitated. His data are most consonant with a combination of the NVN hypothesis and Chomsky's Minimum Distance Principle. We can get one more bit of relevant data by inspecting Gaer's (1969) data obtained from three- to six-year old children in a picture pointing task. Among the sentences that Gaer used were those of the SO and OS type. According to the Interruption hypothesis the former should be more difficult to process. The differences were very slight and almost certainly non-significant. This is, of course, what the Parallel Function hypothesis would predict.

It is possible to get bogged down in all of the experimental minutia and such is not, of course, our intent. It is important to note the discrepancies, however, so that the problem is set out clearly. At the moment we do not know which, if any, of the hypotheses is correct.

Before we go on, let us do just a bit more dissecting on our own. According to Sheldon's hypothesis the two sentences in which the coreferential NPs do not have parallel function should lead to poor performance, and they did. However, they did so in somewhat different ways. If we go back to the data reported in her dissertation (1972) we can obtain performance measures on a clause by clause basis rather than just the overall figures given in her (1974) article. In (6) and (7) the SO and OS sentences are repeated, this time with the average percent correct toy moving responses given after each clause.

(6) SO The dog that the pig jumps over [57%] bumps into the lion [39%].

(7) OS The dog jumps over the pig [85%] that bumps into the lion [34%].

It is apparent that there is a substantial difference in performance on the first clause. This is the result expected by both the NVN and the Interruption hypotheses. In (8) and (9), similar data for the SS and OO sentences are presented.

(8) SS The dog that jumps over the pig [92%] bumps into the lion [54%].

(9) OO The dog jumps over the pig [91%] that the lion bumps into [50%].

It is noteworthy that the first clause scores in (8) and (9) are so similar. This suggests that the presence of the interruption has no effect, exactly Sheldon's conclusion. It is odd, however, to think that the presence of the relative pronoun has no impact on the child's comprehension mechanism. The children are not simply treating the relative clause sentences like conjoined sentences; Sheldon had control conditions which showed that. Perhaps part of the reason why Sheldon obtained the results she did has to do with the toy moving task itself. That task is one in which the response occurs considerably later than does the sentence itself. In order to see whether there was a local effect due to the presence of the relative pronoun, we conducted a word-monitoring experiment.

## Experiment II: Local Effect of Relative Pronouns

The hypothesis with which we undertook this study was that relative pronouns provide a signal to the sentence processing mechanism to enter into a special "sub-routine" for constructing the appropriate syntactic analysis of the input string. In entertaining this hypothesis we were assuming, of course, that we were dealing with sentence processing mechanisms that had acquired such a sub-routine and the appropriate knowledge concerning the valid cues to operate it. We will return to this matter below.

Pre-school subjects were presented with SS and OO sentences like (10) and (11).

(10) SS The woman that kissed the man delighted the clown.

(11) OO The woman kissed the man that the clown delighted.

The target word was the first verb in each sentence, those underlined in (10) and (11). If there is a momentary increase in processing difficulty due to the presence of a relative clause, then word-monitoring RTs should be longer in SS sentences than in OO sentences.

### Method

Materials. The stimuli consisted of a single list of 33 tape-recorded sentences. The first four sentences (two simple and two complex) were practice stimuli. Of the remaining 29 sentences, 16 were experimental and 13 were filler sentences. The experimental sentences were complex, containing an independent and a relative clause. Half of the experimental sentences (designated SS sentences) contained a noun that was the subject in both clauses. The other half of the experimental sentences (designated OO sentences) contained a noun that was the object in both clauses. Each SS and OO sentence contained three animate nouns and two action verbs. SS and OO sentences were paired such that for each SS sentence there was a corresponding OO sentence containing the same nouns and verbs in the same temporal sequence. The nouns and verbs included in the experimental (and filler) sentences were familiar to the children (as ascertained by Thorndike and Lorge, 1944, and by frequency counts and pilot work). In both the SS and OO sentences the target word was the first verb in the sentence. In the SS sentences the target word was preceded only by a definite article (the), an animate noun, and a relative pronoun (that); in the OO sentences the target word was preceded only by a definite article (the) and an animate noun. (See (10) and (11) above for example sentences.)

The 13 filler sentences were of a variety of simple and complex sentence types. In these sentences the target word was either a noun or a verb. The position of the target word was varied from very early to very late in the sentence. Some filler sentences did not contain the target word.

The randomized order of the SS, OO, and filler sentences was constrained by allowing no adjacent SS and no adjacent OO sentences, and by requiring a minimum of eight sentences separating members of SS-OO sentence pairs. Half of the SS members of the SS-OO sentence pairs occurred in the first half of the

list, and the corresponding half of the OO members occurred in the second half of the list. Half of the OO members occurred in the first half of the list.

Procedure. The procedure employed in this experiment was identical to that in Experiment I except for the manner in which comprehension questions were asked. Immediately after the first presentation of each sentence, the experimenter asked a standard sentence comprehension question--"Who 'verbed' who?" (e.g., "Who hit who?") For each child, the verb contained in this question came from the independent clause in some SS and OO sentences and from the relative clause in other SS and OO sentences. If the child gave an insufficient answer to the comprehension question (i.e., some answer other than any noun-verb-noun sequence), the experimenter asked some of the following questions (which particular questions were asked depended on the nature of the child's answers): "Who got hit?", "Who hit?", "Did X hit somebody or did somebody hit X?", "Who did X hit?", "Who hit X?". At no time did the experimenter mention the nouns or the role (subject or object) of the nouns that had occurred in the sentence unless the child had already done so. After the comprehension question had been answered as fully as possible, the next sentence was presented. The subjects were given no feedback concerning the correctness of their answers to the comprehension questions.

Subjects. Thirty-six children enrolled in local preschools served as subjects. Ten of these subjects were dropped from the study for failure to meet the comprehension criterion. Of the remaining 26 subjects (age range = 4.1 - 6:3; median = 5:6), there were 11 boys (range = 4:4 - 6:0; median = 5.6) and 15 girls (range = 4:1 - 6:3; median - 5:5). The children came from predominantly middle and upper-middle class white families.

Design. The design of the experiment included two independent variables. The between-group variable was sex. The within group variable was sentence type (SS and OO sentences).

Two dependent measures were taken. The first dependent measure was reaction time. This measure consisted of the amount of time elapsed between the onset of a target word contained in a sentence and a button-push response by the subject monitoring for that word. The second dependent measure was accuracy of sentence comprehension. This measure consisted of the correctness of the subject's answer to a question about the sentence containing the monitor word.

## Results and Discussion

One notable aspect of the results of Experiment II was that, relative to Experiment I, a smaller proportion of the subjects gave us enough data to analyze. Originally there were 50 children tested. Fourteen of them were omitted immediately because of the large number of (a) failures to respond to the target word, or (b) very long RTs. These children simply did not give us enough data to make a reliable estimate of their RTs.

The RT data from the remaining 36 children were analyzed. The average time to respond to target verbs in SS sentences was, overall, somewhat longer than the average response time in OO sentences. This difference was not statistically

reliable, however, At this point we turned to the comprehension data.

We noted the obvious, that is, that some children did much better on the comprehension test than others. We also noted that the absolute value of the RT data for the good comprehenders was much lower than that for the poor comprehenders. (A good comprehender is a child who gets at least one of the nouns correct in his answer at least 50% of the time.) We had 26 good comprehenders and 10 poor ones. Furthermore, the difference in RT to the two sentence types was greater (see Table 3) and significant (by subjects) in the case of the good comprehenders; $t = 2.38$, $p < .05$. (Because of the post hoc nature of this analysis, we did not compute $F_2$.)

To summarize these data, we found some evidence that subjects who were paying attention to the sentences and who were able to do relatively well on the comprehension task were affected by the presence of the relative pronoun in the sentence. It was as though the word "that" signaled to them that they had to do some extra processing. To again use the computational metaphor, the relative pronoun apparently signaled the children to activate a sub-routine. This activation takes processing capacity, a conclusion we reach by inspecting the RT data. Thus, we found some evidence, albeit slim, that there is an increase in local processing complexity for children when the relative pronoun "that" occurs.

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Insert Table 3 about here

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Even the "good" comprehenders were far from perfect, however. They made many more mistakes than college students or even, say, eight-year olds would. It appears, to continue the metaphor, that the sub-routines are not de-bugged in the case of these pre-schoolers. This observation suggested that the children might be error prone when listening to sentences that bear a superficial resemblance to the relative clause sentences. In other words, pre-school children might not yet have learned which surface cues were valid indicators of a relative clause and which were not. Experiment III was designed to replicate Experiment II and to extend it along these lines.

## Experiment III: Local Effects of "That"

Experiment III made use of sentence types like those shown in (12 - 15).

(12) SS The woman that kissed the man delighted the clown.

(13) OS The woman kissed the man that delighted the clown.

(14) IT That the woman kissed the man delighted the clown.

(15) DOS That woman kissed the man that delighted the clown.

The SS and OS sentences permit a replication of the phenomenon for which we obtained some evidence in Experiment II, namely that sentence processing is momentarily more difficult after the presence of a relative pronoun than when there is no such pronoun.

The other two sentence types (IT and DOS) were included to test the hypothesis that preschool children may be simply using the word "that" as a cue to enter the relative clause processing sub-routine, i.e., that they would overgeneralize by interpreting "that" as an indicator of a relative clause even when it is inappropriate to do so. This appeared to be a reasonable hypothesis since, from the error data, we had good evidence that children around five years of age do not have good control over the relative clause. The children at this age are obviously still acquiring the relative clause construction (especially subject relatives). What this means from the point of view of an information-processing analysis is that they do not yet have the appropriate cues, and the operations attendant upon the occurrence of these cues, well integrated into their sentence processing mechanism.

Consider, for example, the OS sentence which begins with the demonstrative "that." This has been labeled a DOS sentence (=15). We know from the investigations of Limber (1973) that the demonstrative is one of the early constructions that enters into the child's productive vocabulary. It seems unlikely that a sentence beginning with a demonstrative would be harder than one beginning with a definite article--unless the child is confused about the cue value of the word "that," sometimes mistaking it for a relative pronoun. Such mistakes seem likely a priori when the child is in the process of acquiring the relative clause construction (i.e., when the child is adding the capability to deal with this construction to his sentence processor). If such confusion exists, then it seems plausible to predict that RTs will be elevated after demonstrative pronouns. Reaction time will be longer in DOS sentences like (15) than is OS sentences like (13).

The IT sentence (14) presents another case. In sentences of this type the word "that" also signals the presence of an embedded sentence, although the construction type is different, of course. Numerous possibilities exist for how the youthful processing mechanism might affect the measurement technique; the IT sentences were included to see which might receive support. One possibility, for example, is that the IT sentences will behave exactly like the SS sentences on the monitoring task. This might suggest, depending upon the results for the other sentence types, that the effect of the word "that" on the processing mechanism was very short-lived. (Recently, Cairns & Kamerman, (1975), have found that the effects of ambiguous lexical items on phoneme-monitoring in adults are quite transitory.) Other possibilities exist, but we will not explore them here.

In the present experiment we made one major change in methodology; each subject was run in two experimental sessions on two separate days. This was done to get rid of some of the practice effects and thereby to obtain more stable estimates of RT. Each day the children heard sentences exemplifying all four major types, plus fillers.

## Method

Materials. The materials consisted of a list of 30 tape-recorded sentences. The first four sentences (two simple and two complex) were practice stimuli. Of the remaining 26 sentences, 20 were experimental and 6 were filler sentences. There were four types of experimental sentences; all were complex, containing an

embedded sentence. In the sentence list there were five instances of each of the four types of experimental sentences.

One type of experimental sentence (SS sentences) contained a noun that was the subject in both the independent and the relative clause of the sentence. The second type of experimental sentence (OS sentences) contained a noun that was the object in the independent clause and the subject in the relative clause. The third type of experimental sentence (DOS sentences) was identical to the OS sentences except that the initial word of the sentence was a demonstrative ("that") rather than a definite article ("the"). The final type of experimental sentence (IT sentences) contained a sentence-initial relative clause that was the subject of the main clause of the sentence.

Each of the experimental sentences contained three animate nouns and two verbs. The SS, OS, DOS, and IT sentences were constructed such that for each SS sentence there was a corresponding OS, DOS, and IT sentence containing the same nouns and verbs in the same temporal sequence. The nouns and verbs included in the experimental (and filler) sentences were familiar to the children. In the experimental sentences the target word was the first verb in the sentence (the underlined word in examples (12) - (15) above).

The six filler sentences were of a variety of complex sentence types. In these sentences the target word was also a verb. In some filler sentences the target occurred late in the sentence; in others, it did not occur at all.

The sentences were blocked in groups of five or six such that each block contained an SS, OS, DOS, and IT sentence and one or two filler sentences. The randomized order of the sentences within each block was constrained by requiring a minimum of three sentences separating experimental sentences of the same type.

Four material sets of 30 sentences were constructed. Each material set contained the same randomized order of sentences and the same practice and filler sentences. However, corresponding SS, OS, DOS, and IT sentences (the sentences that contained the same nouns and verbs in the same temporal sequence) were placed in different material sets.

Procedure. The procedure employed in this experiment was identical to that in Experiment II except for one major modification. The modification consisted of testing each subject in two separate experimental sessions. One of the four material sets was presented in the first session and a different material set was presented in the second session. An effort was made to present each of the four material sets in the first session (and in the second session) to approximately equal numbers of subjects. The first session was a practice session. Its purpose was to eliminate some practice effects and thereby obtain more stable estimates of RT and sentence comprehension.

The comprehension question ("Who 'verbed' who?") contained the same verb in corresponding SS, OS, DOS, and IT sentences. A minor modification was made in the sentence comprehension question for half of the IT sentences. The question ("Who got 'verbed'?") was asked of the second verb of these sentences rather than the question ("Who 'verbed' who?"), because the latter question was inappropriate.

Subjects. Twenty children enrolled in a local preschool served as subjects. Of the 20 subjects (age range = 4:9 - 5:11; median = 5:3), there were 11 boys (range = 4:9 - 5:11; median = 5:2) and 9 girls (range = 4:11 - 5:10; median = 5:4). The children came from predominantly middle and upper-middle class white families.

Design. The design of the experiment included three independent variables. The between-group variables were (1) sex and (2) material set. The within-group variable was sentence type (SS, OS, DOS, and IT sentences).

The dependent measures were RT and accuracy of sentence comprehension.

## Results and Discussion

There was a very large (177 msec) and significant difference in RTs across the two days. We will concentrate on the data from Day 2 since they are the more reliable. Once again we divided the subjects into two groups on the basis ot their performance on the comprehension test, again focusing upon the good comprehenders since they are the children for whom we have evidence of attentiveness to the task. Most of the children fell into the category of good comprehenders. In order to maximize the validity of the various comparisons that we wanted to make, we selected pairs of sentence types and then chose as subjects just those children who did well on both types. (Recall that by doing "well" we mean that on the majority of sentences the subjects correctly gave one of the two nouns in answer to a question such as, "Who kissed who?" We adopted this criterion since it seemed to include the subjects who were clearly paying attention and trying.) Most of the children were either included in all pairwise comparisons (about 15 - 18 children) or excluded from all of them; but there was some change in the subject composition across the various comparisons of interest.

First question: Did we replicate the earlier finding that "that" leads to a momentary increase in processing difficulty in relative clause sentences? This amounts to asking whether SS sentences led to longer RTs than did OS sentences. The average RTs were 511 msec and 444 msec, respectively. The SS sentences did lead to reliably longer RTs, $F_1(1,14) = 6.13$, $p < .03$; $F_2(1,17) = 11.06$, $p < .01$; and min $F'(1,27) = 3.94$, $p < .07$. Although the min $F'$ value just fails to reach significance, we are prepared to accept it as convincing given the fact that this replicates the earlier finding (using different subjects and materials).

Next question: Is there any evidence that the demonstrative leads to longer RTs, that it may be leading to confusion? Here the answer is far less certain. The difference in RT between DOS (552 msec) and OS (418 msec) sentences is over 100 msec in the direction predicted by the confusion hypothesis. However, this difference did not reach acceptable levels of statistical significance, $F_1(1,13) = 3.58$, $p < .09$; $F_2(1,17) = 5.78$, $p < .03$. The other comparison that might have provided evidence in favor of the confusion hypothesis, IT vs. OS, had $F_1 < 1$. As noted above, there are other reasons for predicting that this latter comparison would not be significant. None of the other pairwise comparisons reached acceptable levels of significance, either.

To summarize the results of Experiment III, we found evidence to support the hypothesis that the presence of a relative pronoun increases the local processing difficulty of the sentence containing it--at least in the preschool child who is in the process of acquiring the relative clause construction. Thus, even though there are no comprehension differences between SS and OO sentences overall, when assessed by the toy moving task, the word-monitoring results lend support to the view that the interruption of a main clause by a relative clause increases processing difficulty. Whether or not one takes this finding to support the Interruption hypothesis depends to a certain extent upon how one interprets this hypothesis (vide infra).

Continuing our summary of the results, we found some evidence which suggests that children who are acquiring the subject relative construction tend to respond to the word "that" as though it is a cue for activating the relative clause subroutine--even when "that" is not actually functioning as a relative pronoun (Overgeneralization hypothesis). The evidence was equivocal, however. This issue was, we felt, worth following up. It appeared that we might have found a developmental performance "dip." That is, it might be the case that younger children would do just fine on the demonstrative sentences (DOS)--until they begin to acquire the relative. Then they may go through a period of uncertainty about the significance of the word "that." This uncertainty would lead to poor performance on both the SS and DOS sentences. (Incidently, these two types did not differ in word-monitoring RTs in Experiment III.) Experiment IV was designed to follow up these issues.

## Experiment IV: Testing the Overgeneralization Hypothesis

Experiment IV tested the Overgeneralization hypothesis in two ways; it was, in effect, two experiments combined into one set of materials and presented to the same subjects. Earlier we remarked that it seemed unlikely that a sentence beginning with a demonstrative would be harder to process than one beginning with a definite article unless the child was confused about the cue value of the word "that." Perhaps that remark was too hasty. Beginning a sentence with a demonstrative does seem somewhat unnatural unless the following noun has occurred earlier in the discourse or unless the referent of the noun is physically present at the time the utterance occurs. Neither of these two conditions obtained in Experiment III. The first of the two sub-experiments remedies this potential deficiance of Experiment III. Sentences like those in (16) and (17) were presented to the children. Again the target word is underlined.

(16) The dog surprised the cat and the cat scratched the child.

(17) The dog surprised the cat and that cat scratched the child.

In (17) the target verb is once again preceded by the word "that" functioning as a demonstrative. However, this sentence meets the naturalness condition stated above. If the word "that" leads to increases in processing difficulty even when it is not functioning as a relative pronoun, then RT should be longer in sentences like (17) than in those like (16).

The second sub-experiment contrasted sentences like those in (18) with sentences such as (19). Targets are underlined.

(18) The boy that the lady spanked bothered the girl.

(19) The boy the lady spanked bothered the girl.

As is obvious, (18) and (19) are identical except for the deletion of the relative pronoun in (19). It has been hypothesized (Fodor, Garrett & Bever, 1967) that the presence of the relative pronoun cues the listener that--with high probability--a relative clause is about to occur. Thus, (18) should be easier to process than (19), at least for adults. In studies using the phoneme-monitoring technique with adult subjects it has been found that RT is shorter when the word "that" is present (and serving its cue function) than when it is deleted (Hakes & Foss, 1970). Note, however, that if the word "that" is signaling to the subjects that they should enter a (for them) complicated sub-routine, then sentences like (18) might actually be harder for the pre-school child to process than sentences such as (19), exactly the opposite pattern of results that we obtain from adults in similar studies. If this were to be the case, if we found an interaction of sentence type with age, it would provide us with some fertile ground for our experimental plows.

## Method

Materials. The materials consisted of a list of 30 tape-recorded sentences. The first four sentences (two simple and two complex) were practice stimuli. Of the remaining 26, 20 were experimental sentences and 6 were fillers. There were four types of experimental sentences, two types for each sub-experiment. Materials for the first sub-experiment consisted of ten sentences each of which consisted of two conjoined independent clauses. The same noun was the object in the first independent clause and the subject in the second. For half of the sentences the subject noun of the second clause was preceded by the demonstrative that (as in (17)). These are designated as D-C sentences. In the other half the comparable noun was preceded by a definite article (as in (16)). These are designated simply as C sentences.

Materials for the second sub-experiment consisted of ten sentences each of which consisted of a main clause and a relative clause. These were all SO sentences; that is, the noun that was the subject of the main clause was also the object of the relative clause. For half of these sentences the relative pronoun that was present in the surface form of the sentence (as in (18)), while for half of them it was omitted (as in (19)). The former are designated as SO sentences; the latter as R-SO sentences.

In the sentence list there were five exemplars of each of the four sentence types. Each experimental sentence contained three animate nouns and two verbs. The sentences were constructed such that for each SO sentence there was a corresponding R-SO sentence and for each D-C sentence there was a corresponding C sentence containing the same nouns and verbs in the same temporal sequence. The nouns and verbs included in the experimental (and filler) sentences were familiar to the children.

In the SO and R-SO sentences the target word was the first verb in the sentence. In the D-C and C sentences the target word was the second verb in the sentence. The sentences were blocked in groups of five or six sentences such

that each block contained an SO, R-SO, D-C, and C sentence and one or two filler sentences. Within each block the order of sentences was randomized.

Two material sets (A and B) of 30 sentences were constructed. Each material set contained the same practice and filler sentences. However, corresponding SO and R-SO sentences, and corresponding D-C and C sentences were placed in different material sets. The same position in the sentence list (e.g., the fifth sentence) was occupied by corresponding sentences.

Procedure. The procedure employed was identical to that in Experiment III. One of the two material sets was presented in the first session and the other was presented in the second session. Half of the subjects were presented material set A in the first session and half were presented material set B.

Subjects. Twenty-eight children enrolled in a local preschool served as subjects. Of the 28 subjects (age range = 5:1-6:7; median = 5:6), there were 14 boys (range = 5:2-6:7; median = 5:7) and 14 girls (range = 5:1-6:4; median = 5:5). The children came from predominantly middle and upper-middle class white families.

Design. The design of the experiment included three independent variables. The between-group variables were (1) sex and (2) material set (two sets). The within-group variable was sentence type (SO, R-SO, D-C, and C sentences).

The dependent measures were RT and accuracy of sentence comprehension.

## Results and Discussion

Once again in reporting the results we will concentrate on the more reliable Day 2 data and the data from those children who gave evidence of attending to the task. With respect to the first sub-experiment, the one that tested the difference between definite articles and demonstratives in the "natural" condition, we have no use for statistics. The mean RTs for these two conditions were 463.6 msec and 464.2 msec, respectively. To say the least, we cannot reject the null hypothesis given these results. Things were no better for the Overgeneralization hypothesis when the data from the second sub-experiment were inspected. Average RT was 504 msec in the sentences with "that" present (supposedly the more troublesome sentences for the children) and 553 msec for the sentences with "that" deleted. Hence, these data were in accord with the results obtained with adults. No age X sentence type interaction is available here.

Taken together, these two sub-experiments lend no support to the Overgeneralization hypothesis. This argues that the suggestive results in the DOS condition of Experiment III were due to the unnaturalness of the sentence-initial demonstrative (or to error).[1] It further suggests that the children who are

[1]Another possibility is that the target words in Experiment IV occurred too far from the word "that" to reflect the momentary difficulty that "that" engendered. By appealing to this explanation we could save the Overgeneralization hypothesis, but it would clearly be post hoc to do so.

acquiring the relative clause construction are finely tuned to the other cues available that permit discrimination between the various functions of "that." These include such cues as intonation and the surrounding lexical items.

## Overview

We have now looked at the results from a series of experiments using the word-monitoring technique. What conclusions can we draw from them? One reasonable conclusion is that the word-monitoring technique works; it can provide information of fine enough grain to help adjudicate theoretical issues. It must be said, however, that the technique is not put forward here as the experimentalist's panacea. It has a number of built-in limitations. For one thing, the age range with which it can be used is limited; it almost certainly will not be suitable for investigating language acquisition much before four years of age. Also, it is a very time-consuming method to use, hence expensive (although in this respect it does not differ much from other available techniques). In addition, it is important that some other independent measure of comprehension be gathered along with the RTs. We need a way of excluding those subjects who are not closely attending to the task. Further, since the variability in the RT data is high, one needs to have either a very powerful variable or else large numbers of subjects and sentences. Because of the attention span of young children, it is difficult to present large numbers of sentences.

Even given these difficulties, however, the word-monitoring technique is promising enough to warrant some brief speculation and questions concerning how it might operate. What is involved when listeners monitor for target words? One obvious requirement is that they hold the target word in mind until they make their response. This undoubtedly puts an atypical load on the listener's working memory. It is theoretically possible to manipulate this load by asking the child to monitor for multiple targets on a single sentence. In practice it is doubtful whether such a manipulation is feasible with preschoolers unless one were willing to look at detection probabilities rather than RTs. In addition to storing the target word, the listener must check each incoming word to see if it is the target. Numerous models for this process are conceivable. Some possibilities are reflected in a set of questions that we could ask about the task. For example, we could ask whether the checking is done against the phonological or semantic code in which the target is represented. If the former, then we should observe false positive responses and longer RTs when the sentences contain words that are phonologically similar to the target word. If the latter, then semantically related words should yield similar effects. We could also inquire about other details of the checking operation--about whether comprehension is easier after the response to the target has been made, about the effects of making the response on comprehension, etc. Each of these questions suggests models and further experiments to test them.

With respect to the issues surrounding the processing of relative clauses, we have seen that the RT data support the following points. First, the concept of "interruption" needs to be clarified. One can have short-term processing difficulty, as indexed by the RT data, without necessarily finding lowered comprehension of the difficult clause when the comprehension measure is taken after the sentence. Second, the data from Experiments II and III support the idea that children find the presence of a subject relative clause to be momentarily taxing. This finding would fit very nicely into the framework suggested by Chomsky that we quoted earlier (p. 16). Recursive calls to the same sub-routine hurt the child's comprehension. This is a happy state of affairs since it

permits a uniform mechanism to account for this aspect of comprehension in both children and adults. There are a number of more precise models of comprehension into which such a finding would be neatly integrated. One promising one is that of the Augmented Transition Network (Woods, 1973; Kaplan, 1972) which has inspired some psychological experimentation on the processing of relative clauses by adults (see Wanner & Maratsos, 1974).

Third, we also have obtained evidence that five-year-old children are sensitive to a range of cues which permits them to discriminate the various functions of "that" very quickly during the processing of a sentence. This suggests that the children are sensitive to such cues as intonation and that they are able to use sentential context to quickly decide what the function of "that" is in any particular sentence. This finding also has developmental implications. It suggests that children do not attempt a large scale reorganization of their processing mechanisms when they are acquiring a troublesome new construction. It is a conservative system.

It is clear that we have not solved the problems of sentence processing in pre-schoolers by utilizing data gathered with the word-monitoring technique. In fact, it seems apparent that data of the sort we have here reported are going to complicate our task of accounting for the acquisition of comprehension. But, we would argue, they are also going to make the stories that we tell about the comprehension process and its development closer to the truth.

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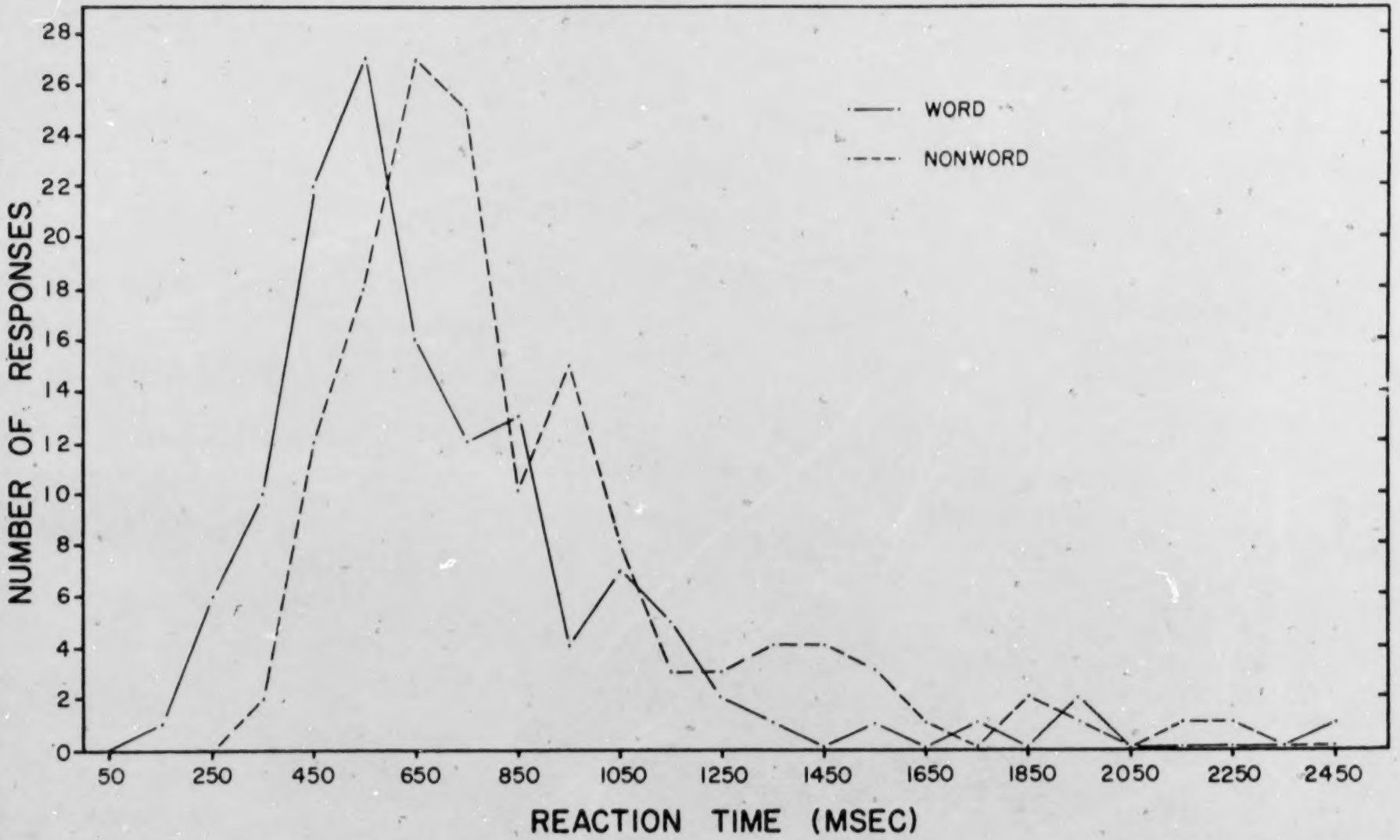
## Figure Captions

Fig. 1 Frequency distributions of word-monitoring reaction times broken down by the word vs. nonword variable.

Fig. 2. Frequency distributions of word-monitoring reaction times broken down by the target form class (and sentence complexity, see text) variables.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14
16
18
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22
24
26
28
50
250
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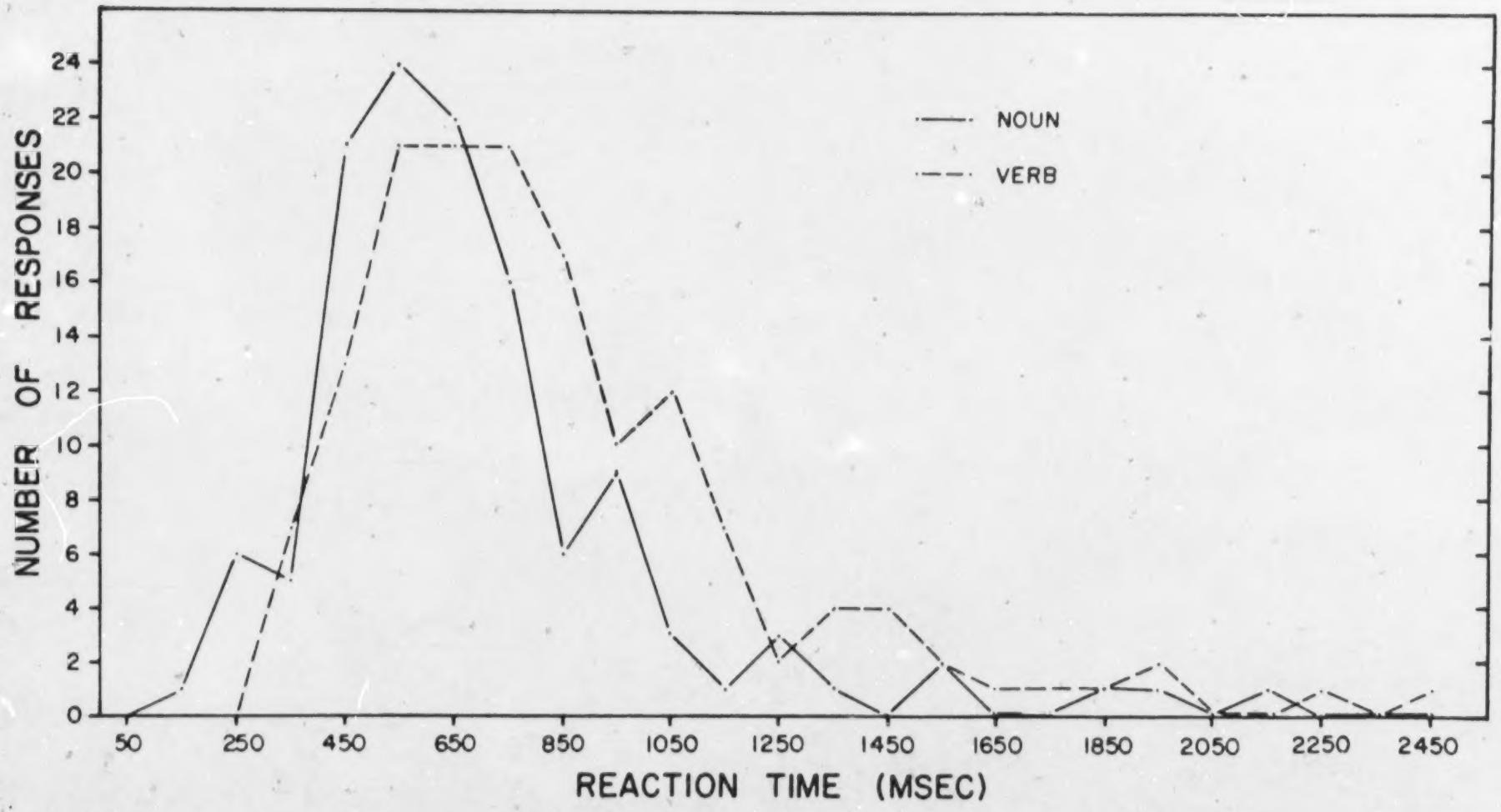
850
1050
1250
1450
1650
1850
2050
2250
2450
REACTION TIME (MSEC)
WORD
NONWORD


NUMBER OF RESPONSES
0
2
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6
8
10
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14
16
18
20
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NOUN
VERB
50
250
450
650
850
1050
1250
1450
1650
1850
2050
2250
2450
REACTION TIME (MSEC)

38

39

Table 1

Sentences Used in the Demonstration Experiment (Expt. I)

Target words are underlined.

| Item Preceding the Target | Target | |
|---|---|---|
| | Noun in Main Clause, Prep Phrase, or For/to Complement Clause. | Verb in that-Complement Clause |
| word | Ernie likes to throw a red ball while Bert runs to catch it. | The nice lady believed that the girl watched the baby during nap time. |
| nonword | ...zed ball... | ...rul watched... |

Table 2

Reaction Times (msec) in Demonstration Experiment (Expt. 1)

| Item preceding The Target | Target | | |
|---|---|---|---|
| | Noun | Verb | $\bar{X}$ |
| Word | 568 | 792 | 680 |
| Nonword | 783 | 884 | 833 |
| $\bar{X}$ | 676 | 838 | 757 |

Table 3

Reaction Times (msec) in Expt. II

| Subject Type | Sentence Type | |
|---|---|---|
| | SS | OO |
| Good (N=26) | 753 | 680 |
| Poor (N=10) | 929 | 887 |